Mystery Encourages Engagement and Interest in Plants

Aditi Sinha, Ph. D

Biology Program
Loras College
Dubuque, IA 52001
Aditi.sinha@loras.edu

Abstract

Active learning pedagogies offer opportunities to increase student engagement and interest in plants. The Mystery Plant Project is a hands-on, semester-long active learning pedagogy I developed for an introductory, undergraduate Plant Biology course. Students investigate various aspects of their mystery plant species using observations, and knowledge and skills acquired through lectures and laboratory sessions. The culmination of this inquiry involves identification of the mystery plant. During the first week, students receive unidentified seeds they germinate and grow in the greenhouse for 14-15 weeks. Students are responsible for determining what to examine and how, interpreting their observations, and their projects' endpoint. The course's structured and scaffolded lecture and laboratory components support student progress on the project. In addition to a comprehensive paper describing their plant's botany, students share their findings in a creative presentation. Students value the hands-on reflective learning approach, practical application of their newfound knowledge, the opportunity to take ownership of their learning, and their enhanced plant awareness. This pedagogical approach offers instructors an alternative strategy to enhance student engagement and curiosity about plants. It can be a valuable tool to address plant awareness disparity and can be integrated into any undergraduate Plant Biology course.

Keywords: active learning, plant biology, plant awareness, plant awareness disparity.

Introduction

The established benefits of active learning pedagogies encompass enhanced understanding and retention of the subject material, increased participation, peer collaborations and application (Allsop et al., 2020; Freeman et al., 2014; Lemelin et al., 2021; Lumpkin et al., 2015). Active learning pedagogies, that allow students to engage and connect with the material, can potentially serve as valuable tools in addressing components of Plant Awareness Disparity (PAD).

PAD continues to be a concern among plant biology educators. It describes the tendency of individuals to overlook plants and not acknowledge their importance to human society. PAD has 4 components that are interconnected: disproportionately low levels of attention to plants than animals, an attitude that plants do not matter, low levels of plant knowledge, and therefore, low relative interest in plants (Parsley, 2020; Wandersee & Schussler, 1999). Various proposed approaches to address PAD include place-based botany education, introduction to biodiverse environments, engagement with plants, and caring for plants (Krosnick et al., 2018; Pany et al., 2019; Stagg & Dillon, 2022). Stagg and Dillon (2022) suggest frequent interactions between individuals and plants that have everyday relevance enhances plant awareness.

Here, I describe a student-centered, active learning pedagogical approach, the Mystery Plant Project (MPP), that offers opportunities for students to interact with plants, thereby fostering engagement, interest and awareness about plants. The objective of the MPP is for students to investigate various biological aspects of a mystery plant (MP) species using semester-long observations, as well as knowledge and skills acquired from lecture and laboratory sessions. The element of mystery in the project sparks student curiosity and encourages further engagement with the material. In addition to promoting active learning, this inquiry-based pedagogy fosters reflective and critical thinking skills in students as they are required to interpret their observations of the MP and cannot generically apply concepts they learn in class. Furthermore, the MPP helps students build important soft skills such as enhanced observation abilities, and transfer of knowledge and understanding from one context to another.

The MPP is a hands-on, semester-long collaborative laboratory project that I have integrated into my 200-level undergraduate Plant Biology course. During the first laboratory session, students receive mystery seeds that they germinate and grow for

14-15 weeks in the departmental greenhouse. Using the knowledge and skills gained in lectures and laboratory sessions throughout the semester, students are responsible for determining what to examine, how to examine, interpreting their observations, and the endpoint of their project. This non-prescriptive nature of the project requires students to be creative, stay actively engaged and take ownership of their learning. Student investigations span an array of topics such as structure, growth, reproductive biology, ecology, and economic botany of their MP. The culmination of the project involves the identification of the mystery plant during the last two weeks of the semester.

The focus of this project and student' observations of their plants can be adjusted to align with the learning objectives of the course this project is integrated into.

The MPP can be integrated into any undergraduate level plant biology course. Students in my Plant Biology course are all biology majors and range from sophomores to seniors. Most of these students are pursuing a health science career and have had limited exposure to plant sciences, and typically low levels of interest in plants. As all the MP species are economically important, the MPP piques students' curiosity to further investigate the relevance of plants in their lives, one of the underlying themes of my course.

Activity

The instructor's pre-laboratory preparation entails ordering seeds earlier in the summer as seeds tend to get sold out. The primary selection criteria for MP are: (i) seed germination within a week, and (ii) flowering within 8-10 weeks of sowing. Over the course of the years, I have experimented with various annual plant species and have found that many cultivars of ornamental and edible plants satisfy these criteria and can be easily purchased from local garden stores or online. Plants that have worked well are species of: *Tagetus*, *Zinnia*, *Petunia*, *Salvia*, *Mimulus*, *Ocimum basicilicum* available from Park Seed (www.parkseed.com) as well as *Phaseolus* (use a bush variety), *Pisum (snow peas and peas)*, *Coriandrum sativum*, *Cucumis sativus*, and *Anethum graveolens* available from Jung Seeds (www.jungseed.com). Some culinary herbs used for the MPP do not flower within the 8-10 week timeframe. Since many of these herbs are grown in our college's community garden, students can use flowers and fruits from these plants to observe reproductive biology and identify the species. If this option is unavailable, the instructor can grow these plants prior to the start of the semester to ensure they flower during the semester. For a MP species that flowers within 4-5 weeks, it is optimal to plant it in two batches since students may not yet have the expertise to identify the species. As such, students can plant half the seeds during the first week of the semester and the remaining during week 4 or 5. Additionally, using bush varieties or non-trailing varieties of the species can also conserve greenhouse space. Approximately 10-12 seeds of any given MP species are placed in a glass vial, along with germination and growth instructions (I cut the instructions on the seed packets to include with the vials, ensuring that the identity of the plant is not revealed). Each vial is assigned a unique number and wrapped in aluminum foil to keep the seeds in darkness. The vials are stored in a cool, dry environment. The instructor should save seeds of each MP species in the event that students need to grow more plants. Table 1 provides a comprehensive timeline of the MPP.

Table 1. MPP timeline and planning

Time and duration	Activity and Description
Prior to week 1; 30-60 min	• Order seeds. • Acquire supplies: potting soil, pots, trays to place pots in and plastic wrap. • Put seeds in numbered vials; include germination instructions. Store in a dark, cool, dry place.
First laboratory session; 1.5-2 hrs	• Start the MPP. • Planting demonstration. Students plant seeds.
~Week 10	Students submit MP paper outline.
~Week 11	Students submit creative presentation plan.
Week 12-14	• Students identify their MP. • Instructor confirms plant identity. Gives cultivar name to each group.
Last laboratory session	Creative presentations.
Last week	Notebook, paper and peer evaluation are due.

During the first lab session, I explain the premise of the MPP, the learning objectives and how it fits into the larger context of the learning outcomes of the Plant Biology course and the Biology Program at Loras College. Ideally, students work in pairs (or in groups of three based on the number of students in lab). Each group has a unique mystery plant species. They select a vial of seeds. The instructor should record the vial number for each group. As most students have little to no plant experience, the seed planting process is demonstrated in the greenhouse. Students are encouraged to sow 6-8 seeds (one seed per pot) which provides them with a safety net in case of plant mortality from disease or pests. All plants can be grown in 10-15cm diameter pots depending on their stature and growth form. As the identity of the plants is only known to the instructor, pots need to be assigned to each group. All required materials are provided to the students. Students grow the plants in the departmental greenhouse for about 14-15 weeks. During the first laboratory session, it is important to discuss plant care and troubleshooting (e.g., detecting pests and diseases, too much or too little watering etc.).

As this is a semester long project, we engage in class discussions to define effective collaboration and establish reasonable expectations for project partners. We create a bulleted list on the whiteboard which sets up the expectations for the entire semester. The pre-laboratory lecture, demonstration and planting take about 1.5-2 hours. In a 3-hour laboratory period, as in my case, I use the last hour of the first laboratory session for a short fun activity, such as a plant scavenger hunt outside.

Students are encouraged to monitor their plants and record observations at least once a week. However, they often opt to do so on Mondays, Wednesdays, and Fridays, the days when lecture class meets. Given that this is an open-ended project, students determine what to observe and explore using the knowledge and skills acquired throughout the semester. They are encouraged to record observations from the day they receive their seeds and maintain a running list of themes/aspects of the MP that can be explored further. Some such themes/aspects maybe, but not limited to, morphology, anatomy, reproductive biology, behavior, ecology, economic- and ethnobotany, and taxonomy. Students are encouraged to be adaptive and creative. For instance, if their plant is a nitrogen-fixer or gets infested with pests during the semester, students can make observations relevant to these themes. Diseases and pests can be a good segue into secondary compound defenses of their MP. The instructor's role should be to facilitate the inquiry.

Students will require guidance to identify their MP species using Gleason and Cronquist (2014). Ideally, students would have been introduced to plant taxonomy and using dichotomous keys in earlier labs in the course. I typically have a dedicated laboratory session towards the last third of the semester for students to work on the MP identification. To facilitate the identification process, I help each group determine the appropriate section key in the manual (some will accomplish this without any assistance); they then identify, either on their own or with minimal assistance, the family, genus and the species using the manual. For plant families with artificial genera keys or group keys, the instructor may need to provide additional support based on the group's capabilities and the plant family involved (for e.g., more assistance may be required for plants in the Asteraceae family). Students identify their MP either to the species level if their species is listed in the manual or to the family/ genus level. In the latter case, students use reliable internet sources such as e-floras

(https://www.missouribotanicalgarden.org/plant-science/plant-science/about-science-conservation/resources-databases/herbarium)

to determine their species' identity. Remarkably, most of the ornamental plant and culinary herb cultivars used in the MPP can be identified using Gleason and Cronquist (2014). Regardless of the identification process, students must provide evidence of how they determined their species' identity. I typically have each group show me the series of dichotomous statement used (e.g. 1b – 2a etc.). Alternatively, this evidence can be part of their paper if time is a constraint. The instructor could also choose to observe students using the dichotomous keys for their identification for credit. Finally, after verifying the identity, I give them their cultivar name. Each group can then conduct research on the ecology, economic botany and secondary compounds of their MP.

Support and scaffolding should be provided throughout the semester. For instance, the topics covered in my lecture and laboratory sessions provide ideas for observations and allow students to apply knowledge and understanding acquired during the semester to their MP. Typically, the sequence of topics covered in lecture coincide with the growth and development of the MP. Various laboratory activities

that students engage in are similar to those they can perform with their MP. For instance, they learn various techniques such as free-hand sectioning, extraction of phytoliths, and examine the morphology, anatomy, and reproductive biology of other plants, that they can apply to their MP. During laboratory sessions that focus on the above-mentioned topics, time is set aside for students to work on their MP. Furthermore, my flipped classroom pedagogy in lecture provides opportunities to tailor several in-class activities to application of lecture concepts to their MP. If more guidance is needed, a laboratory session can be dedicated to working on the MPP towards the end of the semester.

Given that this is a semester-long project, it is crucial to incorporate frequent check-ins throughout the semester. These can be informal (e.g., a brief meeting with each group at the end of a laboratory session during weeks 4-5) or formal (e.g., an outline of the paper and plans for the creative presentation, Appendix A, Table 1). I have found formal check-ins to be valuable in keeping students on task and proving me feedback about where each group is, and the support they need. Alternatively, the check-ins can be conducted as short presentations by each group to share their progress. As students also work on their MPP outside of the lab time, they should have access to materials and stains required for anatomical sections. They should be provided with laboratory safety instructions especially when using stains and razor blades for free-hand sectioning.

In this digital era, where information is readily available, it can be challenging for students to resist using plant identification apps to identify their MP during the initial stages of the project or use the internet as a primary source of information about their plant instead of their observations. Over the fifteen years that I have offered the MPP, I have discovered that clear communication of the project premise, my expectations, and rules for using the internet/AI keeps the mystery in the project. Students are respectful of "the journey is more important than the destination". They are also frequently reminded that the MP identification is just one facet of the project.

Assessment

The assessment of the MPP is based on an observation notebook, paper, creative presentation, and peer evaluation. A detailed description and weighting of each component is included in Appendix A. The observation notebook is a log of all observations a group makes, starting with the day the seeds are sown until the end of the project. It can include drawings, photographs, quantitative data etc. As students' plant knowledge grows, they can revisit their notes to reinterpret their observations. Over the years of offering the MPP, the observation notebook has evolved from a paper notebook to a digital Word document; typically, students will draw diagrams on paper or on their tablets and include them in the Word notebook. I have observed that allowing Gen Z students the freedom to use technology enhances their engagement. However, the instructor may choose to require the submission of a paper notebook.

The goal of the paper is for students to demonstrate an in-depth understanding of their MP's biology and to effectively apply knowledge and skills acquired in lecture and laboratory sessions. It includes labeled images (e.g., photographs, micrographs, diagrams) as evidence of student observations and effort. The paper is typically organized by botanical themes such as growth form and life span, morphology (roots, stems leaves), anatomy, reproductive biology (flower structure, pollination, seed dispersal and germination). However, organization and format are not prescriptive. It is important to communicate to students that the paper should be based on their observations alone, except for their research on economic and ethnobotany, taxonomy and ecology.

The creative presentation is a way for students to showcase their MP in a fun way using their creative abilities (Appendix A). This assessment component was implemented several years ago in response to student feedback. Given that the creative component of the presentation is 3-4 minutes long, it may not capture all aspects and visuals of the MP. As such, students include a brief PowerPoint presentation to share images. The entire presentation is 8-10 minutes long. Students are assessed based on the rubric in Appendix B which is provided to the students during the first week. Creative presentations in the past have included a skit, children's book, poetry slam, haiku, short documentary, museum tour, cooking show, and live musical performances, to name a few. Additionally, students assess the contribution and work ethic of their MPP through a peer evaluation that is accessible to the instructor alone (Appendix C). Peer evaluation accounts for 5% of the MPP grade.

Discussion

The semester long MPP project is designed to foster student interest in and engagement with plants and promote active learning. The process of observing and applying course material towards describing the MP further enhances two important soft skills, required of students in the sciences: (i) making observations, and (ii) transferring and applying knowledge and skills from one context to another rather than compartmentalization of information. Additionally, it provides opportunities to further enhance reflective and critical thinking skills as students are required to connect what they know with their observations. Such active engagement with course material enhances student thinking, understanding and retention (Lumpkin et al., 2015). The open-ended nature of the MPP provides students creativity in determining their project's direction. A balance of creativity and structure nurtures learning (Lemelin et al., 2021;Lumpkin et al., 2015).

In my 15 years of offering the MPP, I have experimented with various project iterations. The version described here best compliments the flipped classroom pedagogy of my course and accommodates the maximum of 20 students in the laboratory setting. However, the project offers flexibility in how it can be adopted. For example, the creative presentation component may be excluded. Alternatively, the oral presentation can be expanded to include all aspects of the MP observed, eliminating the need for a written paper. The project can also be scaled up to work in larger-sized laboratories or for multiple laboratory sections using a similar approach of adopting parts of the project. While the creative presentation adds a fun element for the students and the instructor, it is not a critical element, especially, if there are various other opportunities for developing oral presentation skills in the four-year curriculum. For several years, I offered this project without the creative piece which was just as effective. One potential challenge with multiple laboratory sections could be inadequate greenhouse space. To address this, students could work in groups of three instead of two, which would also make the instructor's workload more manageable. The relative weighting of the various MPP components can also be modified.

Overall, student feedback over the years, indicates that most students value the hands-on opportunities to deeply engage with the material. These opportunities range from growing plants to applying knowledge and skills acquired during the semester to investigate their MP. A recurring theme in student feedback is the opportunity to reflect on their learning and understanding. Table 2 gives a representative sample of student feedback. However, the outcomes the MPP have not been quantified.

In addition to meeting the MPP objectives, this active learning approach offers students an opportunity to be more excited about and invested in plants. Students can take ownership of their project and build a connection with plants through the process of growing and observing them. Some students are surprised by their ability to keep their plants alive throughout the semester and take pride in it. They

Table 2. Typical End of the semester Student Feedback on the MPP from Across the Years

"The mystery plant project was very helpful, and I think that it really gave me a better understanding of all of the plant parts that we learned throughout the semester. It is sort of a daunting task at first because it seems like so much, but it is really not nearly as bad as it seems. I really ended up liking it!"
"the Mystery Plant Project was probably one of my favorite projects I have done as a science major!It made me reflect on the course material more than I probably would have if I didn't have to do the project"
"It allowed me to really think outside the box and it allowed me to use hands-on methods to come to a conclusion. It really helped with my problem solving skills and it was amazing to see how everything tied together."
"it put me in the driver seat and use what I learned to my fullest extent for once and I enjoyed the whole process."
"I was able to learn things outside of class on my own time and apply them to concepts within class. Also led me to think about real life applications of botany."
"It taught me how to look at plants in a completely different way. I am now able to tell people how plants grow, their compounds, how their set up, etc."

have, subsequently, bought plants from garden centers. Others are reminded of their childhood experiences gardening with their parents. Students frequently appreciate the practical application of the knowledge they are acquiring. The project sparks curiosity and excitement, with students reporting that they notice things about plants when walking outside that they previously overlooked, or that they can share, with their friends and family, their newfound knowledge of plants. The MPP offers instructors an alternative approach for making botany more engaging to students who might otherwise edit plants out of their daily lives.

Acknowledgements

I would like to thank my colleagues in the Biology Program, Loras College for their support and students who have participated in the MPP over the years. Their valuable feedback has helped in shaping and refining the MPP.

References

Allsop, J., Young, S. J., Nelson, E. J., Piatt, J, & Knapp, D. (2020). Examining the Benefits Associated with Implementing an Active Learning Classroom among Undergraduate Students. International Journal of Teaching and Learning in Higher Education, 32(3), 418-426.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences of the United States of America, 111(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gleason, H.A., & Cronquist, A. (2014). Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd ed. New York Botanical Garden.

Krosnick, S. E., Baker, J. C., & Moore, K. R. (2018). The pet plant project: Treating plant blindness by making plants personal. The American Biology Teacher, 80(5), 339–345. https://doi.org/10.1525/abt.2018.80.5.339

Lemelin, C., Gross, C. D., Bertholet, R., Gares, S., Hall, M., Henein, H., Kozlova, V., Spila, M., Villatoro, V., & Haave, N. (2021). Mitigating Student Resistance to Active Learning by Constructing Resilient Classrooms. Bioscene, 47(2), 3-9. https://www.acube.org/wp-content/uploads/2022/02/Bioscene-December-2021-20.pdf#:~:text=Volume%2047%20(2)%20December%202021%20Lemelin%20et%20al.:%20Mitigating%20Student

Lumpkin, A., Achen, R. M., & Dodd, R. K. (2015). Student perceptions of active learning. College Student Journal, 49(1), 121–133.

Pany, P., Lörnitzo, A., Auleitner, L., Heidinger, C., Lampert, P., & Kiehn, M. (2019). Using students' interest in useful plants to encourage plant vision in the classroom. Plants, People, Planet, 1(3), 261–270. https://doi.org/10.1002/ppp3.43

Parsley, K. M. (2020). Plant awareness disparity: A case for renaming plant blindness. Plants, People, Planet, 2(6), 598–601. https://doi.org/10.1002/ppp3.10153

Stagg, B.C., & Dillon, J. 2022. Plant awareness is linked to plant relevance: A review of educational and ethnobiological literature (1998–2020). Plants People Planet, 4(6), 579–592. https://doi.org/10.1002/ppp3.10323

Wandersee, J. H., & Schussler, E. E. (1999). Preventing plant blindness. The American Biology Teacher, 61(2), 82–86. https://doi.org/10.2307/4450624